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(54) MARINE SEISMIC STREAMER CABLE

(71) We, WESTERN GEOPHYSICAL COMPANY OF AMERICA, a corporation organised and existing under the laws of the State of Delaware, United States of America, of 336 North Foothill Road, Beverly Hills, California 90213, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to streamer cables for use in marine seismic exploration and, more particularly, to such marine seismic streamer cables composed of mutually interconnectable sections, each section accommodating detectors for detecting reflected shock waves during seismic marine exploration.

Marine seismic streamer cables to detect reflected sound waves are well known in the art. Such cables are described, for example, in United States Patent No. 2,465,696, issued March 29th, 1949, to Lee Roy C. Paslay, and in United States Patent No. 3,299,397, issued January 17th, 1967, to G. M. Pavey, Jr. Typically, a streamer cable is formed of a plurality of detachably coupled, waterproof sections. In streamer cables known heretofore, each section includes spaced, pressure-responsive transducers, such as hydrophones, arranged to form a single array. The seismic signals from the array in each section are carried by a separate pair of conductors forming part of a sectioned cable which runs throughout the entire length of the streamer cable. Each such separate pair of conductors feeds the signals to suitable analog or digital recording equipment on board the ship which trails the streamer cable. While the known streamer cable sections are mutually detachable and interchangeable, the individual hydrophones of a section are permanently mounted and connected one to the others so that no changes in interconnection can be made in the connection pattern of the section, and therefore of the streamer cable formed by interconnecting individual sections.

In accordance with one aspect of this invention there is provided a marine seismic streamer cable comprising a plurality of elongate, mutually interconnectable, sections, each section enclosing at least two distinct, substantially linear, electrically separated or separable arrays of detectors, each array being able to convert water pressure variations caused by seismic disturbances into an electrical signal distinct from the signal of any other array, and transmission lines extending through the sections for transmitting said signals to processing equipment.

In accordance with a second aspect of the invention there is provided a marine seismic streamer cable section interconnectable with other such sections to provide a cable as aforesaid, and comprising at least two distinct, substantially linear, electrically separate or separable arrays of detectors, each array being able to convert water pressure variations caused by seismic disturbances into an electrical signal distinct from the signal of any other array, and portions of said transmission lines for conveying detector array signals to processing equipment.

Detector arrays of different length and/or detector arrays of different positions, taken lengthwise, may be provided within the same cable section. More specifically, the distinct arrays of detectors may be mounted in a spatially overlapping arrangement, so that one array at least partly co-extends with another array within the same length of a cable section.

In accordance with one embodiment of the invention, means are provided for detachably interconnecting detector arrays within one cable section with detector arrays within other cable sections.

In accordance with another embodiment

of the invention, means are provided for detachably interconnecting detector arrays within the same cable section.

Preferably, the detector arrays within each cable section are enclosed between seals, the detachably interconnecting means being plugs, for example, which are mounted externally of the seals. As a result of this arrangement, when one detector array extends through the entire length of one cable section, and a shorter detector array extends through a portion of an adjacent cable section, the plugs permit detachably interconnecting the detector arrays provided in cable sections which, when operatively connected, are mutually adjacent sections. In a specific embodiment of a streamer cable designed for use in this manner, each of the plurality of sections of one cable includes two shorter detector arrays, each extending through substantially one-half of the total length of a cable section.

In accordance with another specific embodiment of this invention, the plugs permit detachable interconnection of distinct detector arrays which extend only through a portion of the entire length of a cable section. Specifically, two distinct detector arrays, each occupying substantially one-half of the total length of a cable section, may be provided. Alternatively, the section, or sections, may accommodate three distinct detector arrays, each occupying substantially one-third of the total length of one cable section.

In any one of the various embodiments described herein, the spacing between detectors in one array may be different from the spacing between detectors of at least one other array in the same cable section. Furthermore, advantageous effects may be achieved by tapering distances between detectors in at least one detector array in a cable section.

Referring now specifically to the embodidescribed herein, the spacing between detector arrays in adjacent sections of a streamer cable formed of individual detachable sections, each section houses a primary array and at least one overlapping secondary array of detectors, each array being arranged to achieve optimum noise rejection and signal selection. Detchable coupling means are operatively connected to the overlapped detector arrays to allow easy, intersection connections, to be made by using external plugs at the end of each section, while maintaining the sections fluidproof. The selectively extendable overlapped detector arrays are used to form composite intersection arrays which yield desirable response curves and allow spatial mixing of inter-array signals.

One of the advantages of this embodiment of the present invention lies in the provision of improved streamer cable sections which allow to selectively and conveniently change the sections' effective array lengths. Another significant advantage lies in the ease with which an array can be changed from a non-tapered to a tapered configuration. A further advantage lies in the ease with which spatial mixing of hydrophone signals can be achieved in seismic streamers.

These advantages are significant in the field, especially when it is advantageous to combine the characteristics of short detector arrays, which provide greater resolution of subsurface detail, with the characteristics of long arrays, which generally have a wider reject band for noise and signals travelling along their axes. Because of the advantageous manner in which the electrical conductors of the detector arrays terminate into detachable coupling means at the end of each section, the sections remain waterproof during the process of making or changing intersection connections. Thus, it is possible to quickly and easily connect and disconnect a number of streamer cable sections in the field to form operable streamer cables of any desired effective length.

Referring now specifically to the other embodiment permitting interconnections between detector arrays in the same section of a streamer cable formed of individual detachable sections, each section houses a primary array and at least one secondary array of detectors, each array being arranged to achieve optimum noise rejection and signal selection. Detachable coupling means are operatively connected to the primary and secondary arrays of detectors, to allow easy, inter-array connection to be made by using external plugs at the end of each section, while maintaining the sections fluid-proof. The selectively extendable intrasection detector arrays form composite arrays which yield desired response curves.

One of the advantages of this embodiment of the present invention, in similarity with the other embodiment, is that it permits the convenient and rapid change of effective array lengths, as discussed above.

The invention, both as to its organization and method of operation, will be better understood from the following description considered in connection with the accompanying drawings, in which presently preferred embodiments of the invention are illustrated by way of example.

In the drawings:

Figure 1 is a schematic, sectional view of a series of streamer cable sections in accordance with one embodiment of the invention, coupled to form a seismic streamer cable;

Figure 2 is a schematic, detailed sectional view of one embodiment of a streamer cable

formed from sections constituting the cable of Figure 1;

Figure 3 diagrammatically illustrates a physical layout of the detector arrays in one streamer cable section of the streamer cable of Figure 1 and Figure 2;

Figure 4 is a schematic, sectional view, similar to that of Figure 1, illustrating another embodiment of the invention;

Figure 5 is a schematic, detailed sectional view of a further embodiment of a streamer cable formed from sections having extendable arrays;

Figure 6 is a schematic, detailed sectional view of the embodiment of Figure 4; and

Figure 7 diagrammatically illustrates a physical layout of the detector arrays in one streamer cable section of the streamer cable of Figure 4 and Figure 6.

Referring to Figure 1, there is shown a seismic streamer cable towed behind a ship 12. A reel 13 on the ship reels out the streamer cable into the water. Paravane, i.e. flotation, means (not shown) are conventionally attached to the streamer cable and arranged to maintain the cable at a predetermined depth below the water surface.

As shown in Figures 1 and 2, the streamer cable is made up of separate sections 16. Each section consists of a very long, flexible pipe 14 (illustrated shortened for the sake of clarity) having end flanges 15. Pipe 14 is made of a suitable flexible plastic material, such as polyvinyl chloride. The flanges 15 of each pair of adjacent pipes are coupled as by a flexible collar 17, to form a detachable joint 18. Sections 16 are constructed to be interchangeable within the streamer cable, hence identical reference numerals are used in the drawings to designate identical parts, for ease of understanding.

In each streamer cable section, near the flanges 15 of pipe 14 are positioned cylindrical end seals 22 and 23. A chamber 24 is thus formed by the volume defined by the inner wall surfaces of pipe 14 and of seals 22 and 23. Chamber 24 is made to contain, in a conventional manner, a suitable fluid, typically light oil. End seals 22 and 23 are made of a relatively hard plastic material, such as neoprene or polytetrafluoroethylene. A sectioned trunkline or cable 20 carries a plurality of conductors 26 forming transmission lines. Suitably, the cable 20 is covered with a protective plastic jacket 27. While only a few conductors 26 are shown, in practice as many as ninety-two or more conductors are used in cable 20.

Cable 20 provides, for each section 16, electrical continuity to a separate pair of conductors 28 which extend substantially along the entire length of section 16. Across conductors 28 are connected in parallel a first plurality of pressure detectors, or hydrophones, 29. The number of hydrophones 29, their individual sensitivity characteristics, and their relative spacings along conductors 28 are selected to meet the requirements of known design criteria and to form a primary array P. The detectors 29 convert pressure variations in the water surrounding the flexible pipe 14 into corresponding electric signals or voltages at pins 30 electrically connected to each end of each of the conductors 28. Thus, primary array P delivers to pins 30 an electric signal e_p which is determined both by the amplitude and phase of each signal generated in each detector 29.

In accordance with this embodiment of the present invention, at least two other pairs of conductors 40 and 50 are provided within each chamber 24, and across conductors 40 are again connected in parallel a second plurality of detectors 41, while across conductors 50 are connected in parallel a third plurality of detectors 51. Preferably, the detectors, i.e. hydrophones, 41 are non-uniformly spaced along conductors 40 and extend from one end seal toward the center of section 16 to form a first secondary array S_1. On the other hand, hydrophones 51 are preferably non-uniformly spaced along conductors 50 and extend from the other end seal toward the center of section 16 to form a secondary array S_2. Tapered, or weighted secondary array S_1 produces, in response to water pressure variations, a resultant electric signal e_{s1} at pins 42 which are electrically connected to conductors 40. Similarly, tapered array S_2 generates a resultant electric signal e_{s2} at pins 52 which are electrically connected to conductors 50.

Primary array P and secondary arrays S_1 and S_2 are enclosed in the fluid-proof chamber 24. Other elements, such as strain cables, spacers, et cetera, which are conventionally provided in streamer cable sections 16 are omitted from the drawings for the sake of clarity. Conductors 28, 40, 50 and transmission line cable 20, as well as such other elements (not shown) pass through the end seals 22 and 23 in a leak-proof manner.

Progressing now to a more detailed description of how the pins mentioned thus far are accommodated in plugs to permit forming the desired interconnections, it can be seen, particularly from Figure 2, that the inner cylindrical wall surfaces of flanges 15 and the outer wall surfaces of end seals 22 and 23 form open-ended chambers 43, 44, respectively. Positioned in each chamber 43 are: a male plug 45 carrying pins 46 electrically connected to conductors 28, a male plug 47 carrying pins 30 and a male plug 48 carrying pins 42. Positioned in the adjacent chamber 44 are: a female plug 45[1]

carrying pins 46' electrically connected to one pair of the conductors 26, a female plug 47' carrying pins 52 and a female plug 48' carrying pins 31. When cooperating pairs of plugs 47, 47' and 48, 48' are disconnected, the secondary arrays S_1 and S_2 in that section are "floating", i.e. no signal is derived and applied through transmission lines of cable 20 to the processing equipment. On the other hand, when plugs 45, 47 and 48 are respectively coupled with their mating plugs 45', 47' and 48', the electric signasl e_{s1} and e_{s2} from the first and second secondary arrays are combined with the electric signal e_{sp} from the primary array to yield a composite electric signal e_c which is transmitted by an individual pair of conductors 54, 56, through the transmission line 20 to an individual channel in the recording or processing equipment on board ship 12. The composite electric signal e_c is the combined output of all detectors 29 of a composite array C consisting of a primary array P in one section and of secondary arrays S_1 and S_2 in adjacent sections, all connected in parallel. Since the detachable coupling means, in the form of plugs 45, 47 and 48 and their mating counterparts 45', 47' and 48', are positioned within the open-ended chambers 43, 44, both the integrity of the primary and secondary arrays and the fluid-proofness of chamber 24 are preserved during the coupling procedure.

In operation, the field operator can easily extend the primary array P of one section into a composite array C which extends substantially to the center of each of the two adjacent sections merely by coupling plugs 47 and 48, at the ends of each section 16, with plugs 47' and 48'. The operator then couples plug 45' and brings both flanges 15 of adjacent sections 16 together end-to-end, slides collar 17 forming the joint 18 into position to render chambers 43, 44 waterproof. To maintain collar 17 in place, suitable clamps (not shown) may be used.

Because each primary array P is coupled to at least one secondary array which overlaps a substantial portion of the primary array of an adjacent section, desirable spatial signal mixing or averaging is achieved. The mixing of signals in this manner conveniently yields seismic records of greater clarity and continuity. As previously mentioned, secondary arrays S_1 and S_2 may be tapered to achieve higher resolution of signals of certain selected frequencies and hence of subsurface detail. A tapered array can also be designed to provide optimum response within a predetermined frequency pass band and maximum attenuation of noise within that band.

It is therefore apparent from the foregoing description that the streamer cable sections have arrays the parameters of which can be easily altered in the field to achieve signal mixing, optimum signal response and maximum noise attenuation. Because of the advantageous manner in which the detachable coupling means are positioned outside the waterproof chamber, the connections are easily and conveniently performed in the field. Also, since sections 16 are interchangeable, any number of such sections can be interconnected to form relatively long streamer cables. In practice, twenty-four, thirty-six or forty-eight sections are coupled together to provide corresponding signals to recording channels on board ship 12. In a twenty-four section streamer cable, for example, the first and last sections have one of their secondary arrays "floating". Hence, such a streamer can only have twenty-two composite detector arrays.

Figure 3 illustrates a preferred dimensional layout of the sections shown in Figure 2. The total length of each primary array P is about two hundred thirty feet. Each of the secondary arrays S_1 and S_2 is about one hundred eight feet long. Primary array P has twenty-five detectors, i.e. hydrophones, and each of the secondary arrays has six hydrophones. The inter-hydrophone spacings in the secondary arrays decrease from the center of the primary array toward the ends of section 16, in accordance with a desired tapering function.

Proceeding now to a detailed description of embodiments of this invention which permit forming connections between distinct detector arrays within the same streamer cable section, reference is made to Figure 4, which, in similarity to Figure 1, generally illustrates a seismic streamer cable towed behind the ship 12. A reel 13 on the ship reels out the streamer cable into the water.

Likewise, as described in conjunction with the embodiment of Figures 1 and 2, the streamer is made up of separate streamer cable sections 16, each section consisting of a very long, flexible pipe 14 having end flanges 15. Pipe 14 is made of a suitable flexible plastic material, such as polyvinyl chloride. The flanges 15 of each pair of adjacent pipes 14 are coupled one to the other as by a flexible collar 17, to form a detachable joint 18. Each section 16 accommodates a plurality of distinct arrays, schematically illustrated as blocks 21, of pressure detectors, or hydrophones, adapted to detect pressure variations in the water caused by the detonation of explosive charges (dynamite or gases) or by other known energy sources. At the ends of pipe 14 are provided detachable coupling means 145 and 150, corresponding to the plugs of Figures 1 and 2 to permit connection to the transmission lines of cable 20, for transmitting the electric signals generated by the detector arrays 21 to individual channels in

the recording equipment (not shown) carried on ship 12. Sections 16 are constructed to be interchangeable within streamer 10. Thus far, the arrangement essentially corresponds to the embodiment of Figures 1 and 2, except for the mutual alignment configuration of detector arrays 21 without spatial overlapping.

While Figure 4 illustrates the physical arrangement in a schematic manner, one modification of this embodiment is shown in Figure 5 to explain the electrical layout, this modification including two distinct detector arrays within one streamer cable section, each array occupying a half-length of the section.

As can be seen in greater detail in Figure 5, near the flanges 15 of pipe 14 are positioned cylindrical end seals 22, 23. In this embodiment, too, a chamber 24 is formed by the volume defined by the inner wall surfaces of pipe 14 and of seals 22, 23. Chamber 24 is made to contain, in a conventional manner, a suitable fluid, typically light oil, and the end seals 22, 23 are made of a relatively hard plastic material, such as neoprene or polytetrafluoroethylene. Transmisison line cable 20 consists of a plurality of electric signal carrying conductors 26, which may be covered by a protective plastic jacket 27. While only a few conductors 26 are shown, in practice as many as ninety-two or more conductors are used to form cable 20.

In further similarity with the embodiment of Figures 1 and 2, cable 20 provides a pair of transmission lines to each section 16 connectable to a separate pair of conductors 128 across which are connected in parallel a plurality of pressure transducers, or hydrophones, 129. Hydrophones 129 convert pressure variations in the water surrounding the flexible pipe 14 into corresponding electric signals or voltages which appear at male pins 130 electrically connected to conductors 128. The number of hydrophones 129 connected in parallel, their individual sensitivity characteristics, and their relative spacings along conductors 128 may be selected to meet the requirements of known design criteria. On the other hand, hydrophones 129 may have the same characteristics and may be uniformly spaced along conductors 128. After the characteristics of hydrophones 129 are selected and their layout pattern determined, hydrophones 129 form a primary array P. Primary array P delivers to pins 130 an electric signal e_p representing the combined output signals from hydrophones 129. Signal e_p at pins 130 is determined both by the amplitude and phase of each signal produced by each of hydrophones 129 forming primary array P.

In accordance with this embodiment of the present invention, at least one other pair of conductors 140 is provided within each chamber 24, and across conductors 140 are again connected in parallel a plurality of hydrophones 141. Preferably, hydrophones 141 are so selected and positioned along conductors 140 as to form a weighted secondary array S_1. Again, hydrophones 141, in response to water pressure variations, generate individual electric signals which are combined to produce a resultant electric signal e_{s1} at male pins 147. Thus, for each primary array P producing a primary resultant electric signal e_p, there is a secondary array S_1 producing a secondary resultant electric signal e_{s1}.

As mentioned above, primary array P and secondary array S_1 are enclosed in oil-proof chamber 24, while other elements, such as strain cables, spacers, et cetera, which are conventionally provided in streamer cable sections, are omitted from the drawings for the sake of clarity. Conductors 128 and 140, cable 20, as well as the mentioned other elements (not shown), pass through the end seals 22 and 23 in a leakproof manner. The inner cylindrical wall surfaces of flanges 15 and the outer wall surfaces of end seals 22 and 23 form open-ended chambers 43, 44, respectively. Positioned in chamber 43 is the multi-pin male plug 145 which, in addition to housing pins 130, also houses pins 146 terminating conductors 26 of transmission line cable 20. Also provided in chamber 43 is a male plug 147 carrying pins 142 and a female plug 148 carrying pins 149 which are electrically connected to conductors 128.

When plugs 147 and 148 are disconnected, the secondary array S_1 is "floating", i.e. inoperative. On the other hand, when plugs 147 and 148 are connected, the secondary signal e_{s1} is combined with the primary signal e_p to yield a composite electric signal e_c at pins 130. Thus, it is possible to selectively provide a relatively short primary array P or a relatively long composite array C_1 consisting of the detectors of arrays P and S_1 connected in parallel. Since the selective coupling or decoupling of intra-section arrays P and S_1 is performed within open-ended chamber 43, both the integrity of the detector arrays and the oil-proofness of chamber 24 are preserved.

In the open-ended chamber 44 of the adjacent streamer cable section 16, there is provided a multi-contact female plug 150 carrying pins 151 for detachably connecting with the corresponding pins 146 of male plug 145. Female plugs 150 are also provided with female pin contacts 152 for receiving pins 130, thereby to channel the signals through one pair of transmission line conductors 26 to the processing equipment. Thus, when plugs 145 and 150 are con-

nected to each other, either the electric signals delivered solely by the primary array P or signals produced by the composite array C_1, depending on whether plugs 147 and 148 are disconnected or interconnected, will be transmitted through cable 20 to an individual recording channel within the recording equipment on ship 12. To establish the joint 18, both flanges 15 of adjacent sections 16 are brought together end-to-end. Collar 17 is then placed over flanges 15 to provide a leakproof joint 18. Suitable clamps (not shown) may be added for additional sealing protection.

Figure 6 illustrates a preferred modification of this embodiment of the invention, wherein section 16, in addition to primary array P, has at least two secondary arrays S_1 and S_2. As a total number of three detector arrays is shown, Figure 6 may be designated a detailed showing of the arrangement schematically shown in Figure 1. Except for the addition of secondary array S_2, and suitable coupling means therefor, the modification shown in Figure 6 is, in all respects, similar to the one shown in Figure 5.

It should be noted that connections to transmission line cable 20 have been omitted from Figure 6 for the sake of clarity, as they must obviously be provided for channelling signals to the processing equipment, and this is achieved in a conventional manner.

There is now provided in chamber 24 another pair of conductors 140^1 across which are connected in parallel a plurality of hydrophones 141^1 to form the secondary array S_2. Because the second secondary array S_2 is conveniently made the image of the first secondary array S_1 with respect to the center of primary array P, the numerals assigned to elements connected with the secondary array S_2 are the same as their corresponding parts connected with the first secondary array S_1 but with a prime added. Thus, it will now be appreciated that the field operator can provide to pins 130 the output signal e_p of primary array P, or the composite output signal e_{c1} formed of e_p and e_{s1}, or the composite signal e_{c2} formed of e_p, c_{s1} and e_{s2}.

In other words, the field operator can easily extend the primary array P into a first composite detector array C_1, consisting of arrays P and S_1, or into a second composite detector array C_2, consisting of arrays P, S_1 and S_2. Primary array P is therefore extendable inside each section into composite arrays C_1 and C_2, the elements permitting selection of interconnections being located at the end of each section outside the waterproof chamber 24. Secondary arrays S_1 and S_2 can be conveniently tapered to achieve higher resolution of certain selected frequency signals and hence of subsurface detail. Moreover, since the streamer cable sections 16 are interchangeable, they can be easily assembled, much like building blocks, into full streamer cables by assembling a great number of cable sections with the desired electrical connections followed by forming the joints 18 with collars 17.

It is therefore apparent from the foregoing that the hydrophone arrays have configuration parameters which can be easily altered in the field and in which mathematically or experimentally determined interhydrophone spacings are so optimized as to provide maximum noise rejection throughout the entire frequency band of interest. The arrays can be used in either tapered or nontapered configurations by merely performing minor interconnections in the field. Yet another advantage of this embodiment of the present invention is that the extendable interasection arrays can be easily interconnected to adjoining extendable arrays to selectively form desirable lengths of hydrophone array configurations.

Figure 7 schematically illustrates a configuration layout of the extendable interasection hydrophone arrays shown in Figure 6. The total length of the composite detector array C_2 is about two hundred ten feet. The primary array P is about ninety feet long, and each of the secondary arrays S_1 and S_2 is about sixty feet long. Primary array P may have twenty hydrophones evenly spaced, and each of the secondary arrays S_1 and S_2 may have six hydrophones. The inter-hydrophone spacings in the secondary arrays increase from the center of streamer cable section 16 toward the ends of section 16, in accordance with a desired tapering function. Thus, the primary array P can be conveniently extended into a tapered array C_2.

WHAT WE CLAIM IS:—

1. A marine seismic streamer cable comprising a plurality of elongate, mutually interconnectable sections, each section enclosing at least two distinct, substantially linear, electrically separated or separable arrays of detectors, each array being able to convert water pressure variations caused by seismic disturbances into an electrical signal distinct from the signal of any other array, and transmission lines extending through the sections for transmitting said signals to processing equipment.

2. A streamer cable according to claim 1, and having substantially linear detector arrays of different lengths within the same section.

3. A streamer cable according to claim 1 or claim 2, and having detector arrays at different positions, considered lengthwise, within the same section.

4. A streamer cable according to claim 1, claim 2 or claim 3, wherein two distinct, substantially linear, arrays of detectors of a section are mounted in a spatially overlapping arrangement, so that one array at least partly co-extends with another array over the same length of a cable section.

5. A streamer cable according to any one of the preceding claims, and comprising means for detachably interconnecting detector arrays within one section with detector arrays within other sections.

6. A streamer cable according to any one of claims 1 to 4, and comprising means for detachably interconnecting detector arrays of the same section.

7. A streamer cable according to claim 5 or claim 6, wherein the detector arrays within each section are enclosed between end seals, the detachably interconnecting means being connectors which are mounted externally of the seals.

8. A streamer cable according to claim 5, and including at least one detector array extending substantially throughout the length of a section, and at least one shorter detector array in another section, the connecting means permitting detachably interconnecting these two detector arrays.

9. A streamer cable according to claim 8, wherein each of the plurality of sections of the cable includes two shorter detector arrays, each extending through substantially one-half of the total length of its section.

10. A streamer cable according to claim 6, wherein at least one of the distinct arrays extends only through a portion of the length of its section.

11. A streamer cable according to claim 10, wherein, of two distinct detector arrays in one section, one array occupies substantially one half, and the other array occupies the other half, of the total length of a section.

12. A streamer cable according to claim 10, wherein a section has three distinct detector arrays, at least one of which occupies substantially one-third of the total length of the section.

13. A streamer cable according to any one of the preceding claims, wherein the spacing between detectors in one array is different from the spacing between detectors of at least one other array in the same section.

14. A streamer cable according to any one of the preceding claims, and having tapering distances between the detectors of at least one of two detector arrays.

15. A marine seismic streamer cable section interconnectable with other such sections to provide a cable according to any one of the preceding claims, and comprising at least two distinct, substantially linear, electrically separate or separable arrays of detectors, each array being able to convert water pressure variations caused by seismic disturbances into an electrical signal distinct from the signal of any other array, and portions of said transmission lines for conveying detector array signals to processing equipment.

16. A streamer cable, or cable section, substantially according to any one of the embodiments hereinbefore described with reference to the accompanying drawings.

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1230701 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

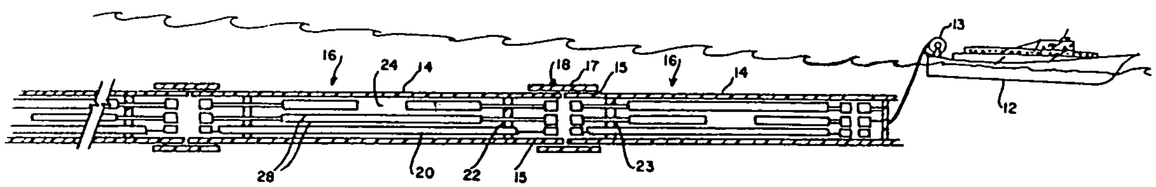


Fig. 1

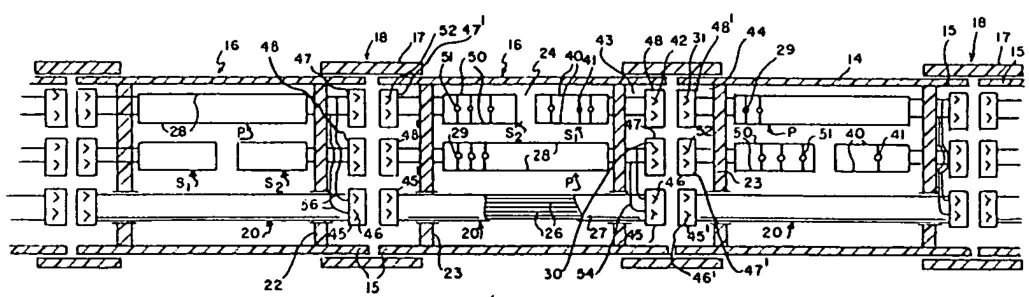
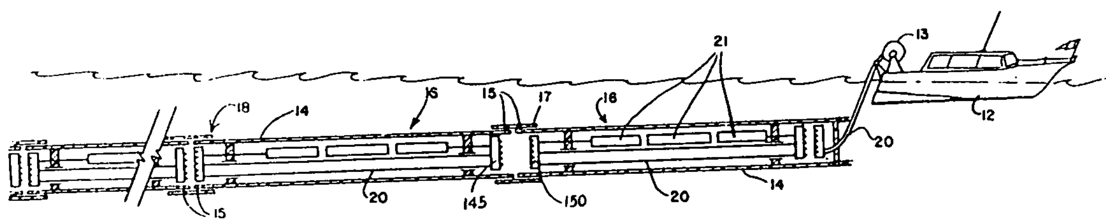


Fig. 2


21
13
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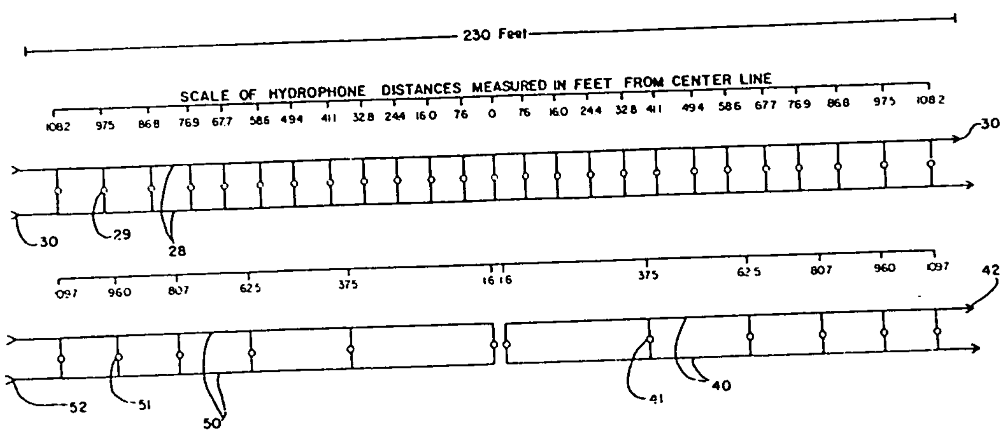
145
150

Fig 4


230 Feet
SCALE OF HYDROPHONE DISTANCES MEASURED IN FEET FROM CENTER LINE
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30
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1097 960 807 625 375 16 16 375 625 807 960 1097
42
52
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Fig 5

Fig. 5

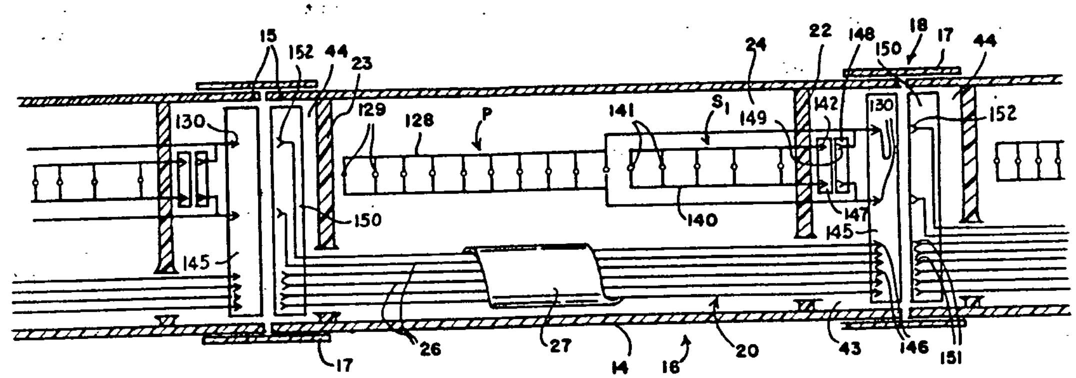

Fig. 6

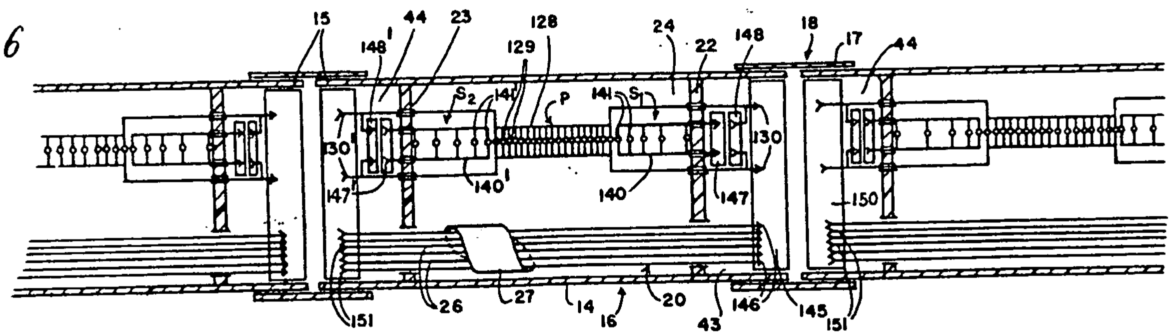

Fig. 7